

Figure 3

Probabilistic Risk Assessment

A probabilistic risk assessment was performed on the baseline schedule and estimate. The outcome is a range of schedule completion dates and estimated costs as well as the likelihood of achieving that particular result. Specifically, each individual cost and schedule item was evaluated based on Program-to-Date cost and schedule performance as well as professional judgment. An estimated best case and worst case scenario (i.e., uncertainty) was added to the baseline's most likely scenario providing the range of cost (estimated cost value) and schedule (estimated duration) criteria as shown in Figure 4. In this case, a range of 95%-125% was utilized. These cost and schedule uncertainties were modeled utilizing a 'Monte Carlo simulation', randomly selecting values within the ranges identified for each item and calculating estimated costs and schedule completions for the program. The simulation included 10,000 iterations that resulted in a probability distribution of possible outcomes – how likely a certain cost estimate and schedule completion combination will occur. The 80% probability values (P80) were selected for the program objectives.

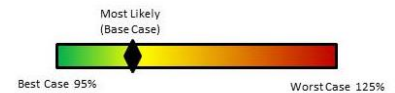


Figure 4

P80 Baseline Schedule and Estimate

The results of the Monte Carlo simulation on the Baseline Schedule and Cost Estimate are shown in Figure 5. The margin of error for this simulation is $\pm 0.1\%$.

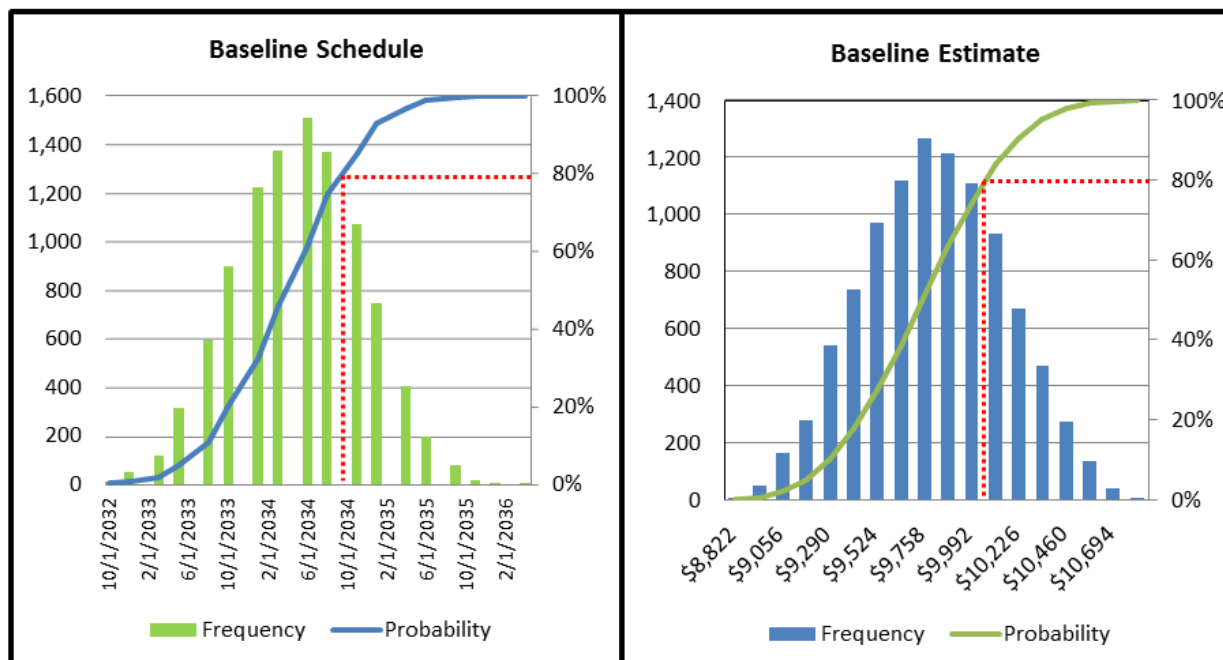


Figure 5

The P80 schedule completion is 4Q2034. The variance from the deterministic Baseline Schedule date of 2Q2032 is 880 days. The estimated remaining duration of the deterministic Baseline schedule is 6,400 days (1Q2015 – 2Q2032). Based on this simulation, the deterministic date of 2Q2032 has a 1% probability of occurrence.

The P80 estimated cost is \$10.1 billion. The variance from the deterministic Baseline Estimated Cost of \$8.9 billion is \$1.2 billion. Based on this simulation, the deterministic Baseline Estimated Cost of \$8.9 billion has a 1% probability of occurrence.

Program Contingency

Contingency is a cost and time allowance of unknowns within the known scope of work. Program contingency, controlled by PGL, is the difference between the P80 cost and schedule and the baseline schedule as shown in Figure 6.

For this program, a cost contingency of \$1.2 billion ($\$1.2 / \$8.9 = 13.5\%$) and schedule contingency of 30 months ($880 \text{ days} / 6,400 \text{ days} = 13.8\%$) is recommended.

The program will continue to work the baseline schedule, recognizing that over time, unknowns within the known scope will result in increases in cost and schedule.

The accuracy of an estimate or schedule is the amount of fluctuation a single line item can experience and typically reflects the level of design

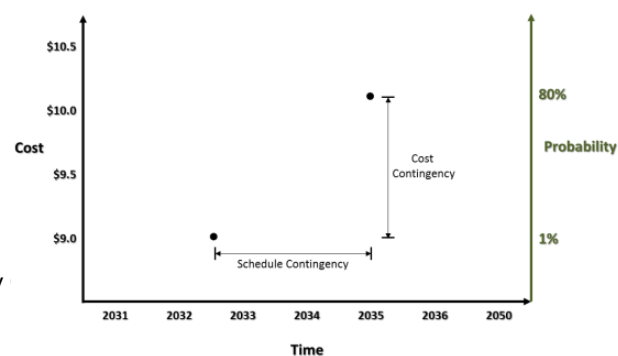


Figure 6

complete, procurement pricing secured and other project factors. The accuracy of this estimate and schedule is $\pm 25\%$, meaning a single line item (or neighborhood) cost and schedule can fluctuate up to 25% in either direction, but the overall bottom line cost and schedule will remain unchanged, given the contingencies incorporated into the program.

The Cost of Delay - At this early stage of the program, the cost of extending the schedule is significant. Currently, the cost of one year of escalation is over ~\$100 million. This results in a cost per work day of over \$400,000. While this number decreases as the program advances, seemingly insignificant schedule delays now, without corresponding recovery efforts, can quickly add millions to the overall program cost.

Baseline and P80 Annual Spend Plan

The time phased spend plan on the P80 estimate and schedule is shown in Figure 7. The average annual spend is ~\$469 million per year. The highest spend in ~\$735 million in year 2029, the lowest spend is ~\$257 million in year 2019.

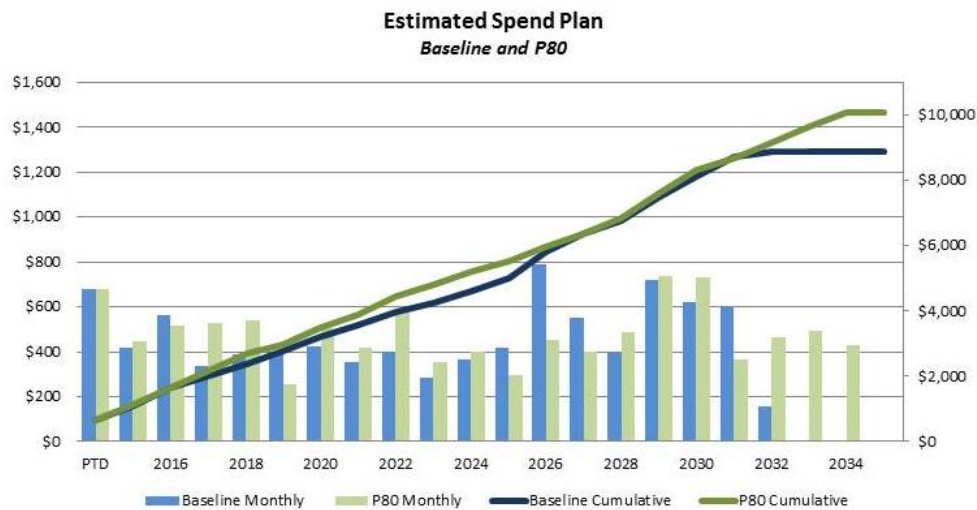


Figure 7

Resource Levelled Schedule

When the baseline schedule is adjusted for resource limitations, the overall completion date and estimated cost increase. To effectively resource level the program, select neighborhood to neighborhood interdependencies were incorporated into schedule. Specifically, logic ties between neighborhood meter installations (ie, neighborhood A meters to neighborhood B meters) as well as between neighborhood

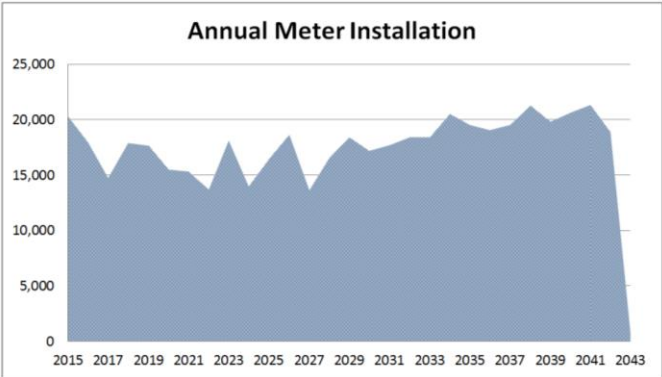


Figure 8

main installations (ie, neighborhood A mains to neighborhood B mains) were incorporated. The program schedule completion date with resources leveled for a maximum of 22,000 meter installations per year is 1Q2043. The required annual productivity requirements for meters, the driving installation component, are shown in Figure 8.

This deterministic Resource Levelled Schedule is nearly 11 years longer than the Baseline estimated completion of 2Q2032.

P80 Resource Levelled Schedule and Estimate

The results of the Monte Carlo simulation on the Resource Levelled Schedule and Cost Estimate are shown in Figure 9. The margin of error for this simulation is $\pm 0.1\%$.

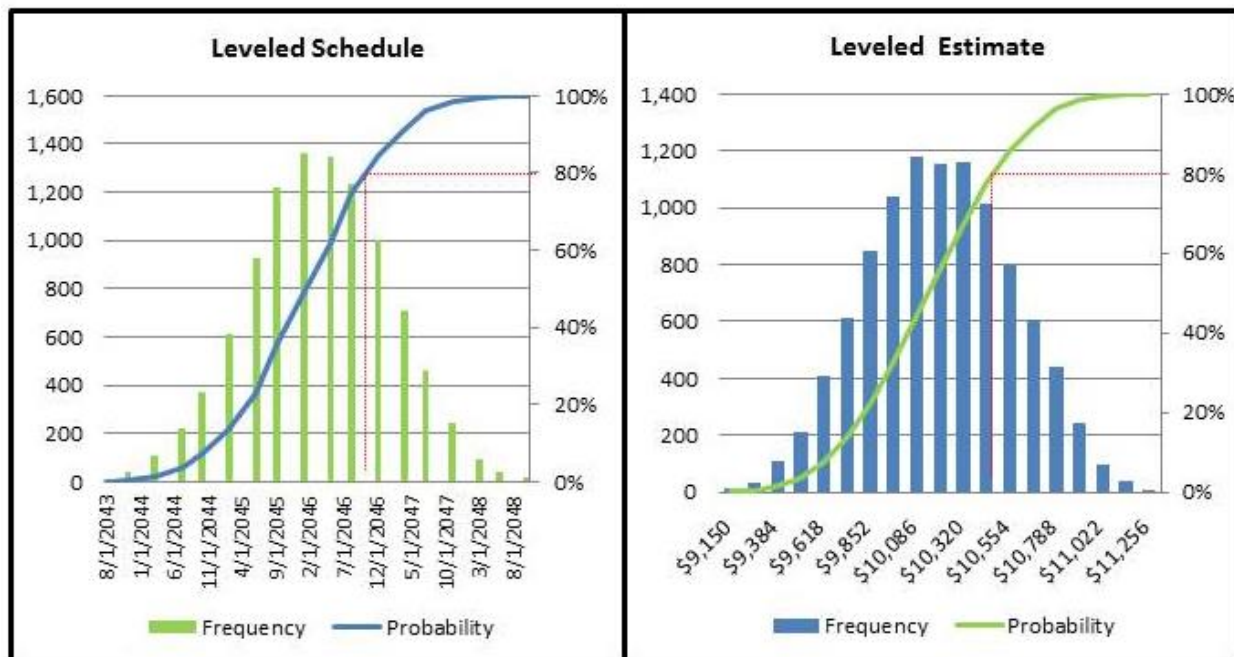


Figure 9

The P80 schedule completion is 4Q2046. The variance from the deterministic Resource Levelled Schedule date of 1Q2043 is 1,300 days. The estimated remaining duration of the deterministic Resource Levelled Schedule is 10,300 days (1Q2015 – 1Q2043). Based on this simulation, the deterministic date of 1Q2043 has a 1% probability of occurrence.

The P80 estimated cost is \$10.5 billion. The variance from the deterministic Resource Levelled Estimated Cost of \$9.2 billion is \$1.2 billion. Based on this simulation, the deterministic Resource Levelled Estimated Cost of \$9.2 billion has a 1% probability of occurrence.

For the Levelled Resource Estimated Cost and Schedule, a contingency of XX% and XX% respectively is required.

Resource Leveled and P80 Annual Spend Plan

The time phased spend plan on the baseline estimate and schedule is shown in Figure 3 below. The average annual spend is ~\$325 million per year. The highest spend is ~\$615 million in year 2026, the lowest spend is ~\$110 million in year 2035, excluding the 3 months at the end of the program (2043).

The time phased spend plan on the P80 estimate and schedule is shown in Figure 10 below. The average annual spend is ~\$315 million per year. The highest spend is ~\$418 million in year 2031, the lowest spend is ~\$211 million in year 2035.

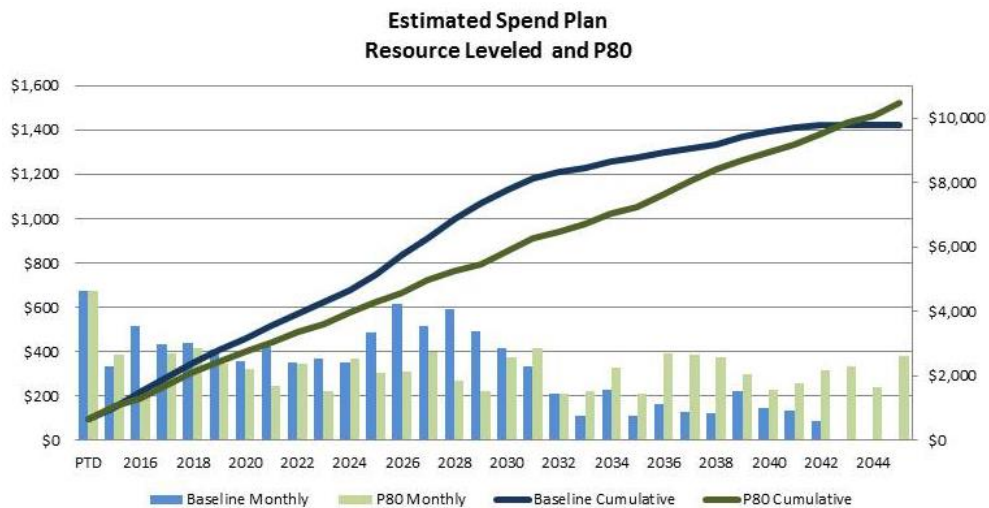


Figure 10

Program Cost and Schedule Drivers

Without interdependencies between the neighborhoods, a true critical path for the program cannot be determined. However, Program to Date information and resource requirements indicate a number of key schedule drivers.

- **Meter Installation Resources** - The primary drivers for the Baseline 2Q2032 schedule are available resources to install meters. Figure 11 reflects necessary resources to meet the various needs of the program as well as the other PGL requirements. The green area illustrates current needs to support a 22,000 meters per year. The yellow/red illustrates the over-allocation of resources required to support a 2Q2032 deterministic Baseline schedule. The gray/white represents the current O&M, system and compliance requirements. These requirements are estimated with no actual headcount identified.

- Main Installation Resources – The deterministic Baseline Schedule also revealed a resource shortage for main and service installation (pipefitters), though not as severe as meters. A productivity increase of 60% in Years 2026-2028 to support the 2Q32 completion date.

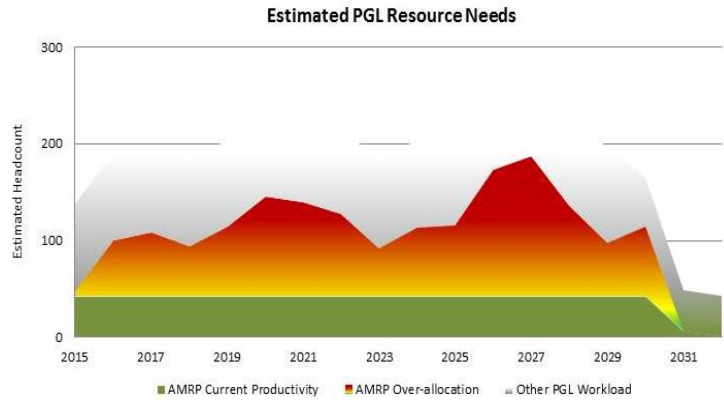


Figure 11

- Permitting – The program will require an estimated 141,000 permits. To date, the permit requirements continue to evolve through the City, including additional requirements and closer scrutiny of submittals. This, coupled with the performance issues of the program as well as O&M and COSIPSE issues has resulted in inconsistent release of permits resulting in delay, which can add significant cost to the overall program.
- 3rd Party Engineering – The quality of deliverables and schedule adherence by the various firms providing engineering services has resulted in delayed or re-sequenced procurement.

Actions / Opportunities

A number of recommended actions to improve the baseline cost and schedule are listed below. The items identified in **bold blue** include recommended reductions as well as potential cost and schedule savings. It is important to remember that the schedule savings will not necessarily translate as a day-for-day reduction in the program schedule.

Action / Recommended Target	Cost Savings Range / Target	Work Week Savings* / Target
1. Reduce number of intersections impacted by program / 20% (4,800 ea)	\$120K - \$700M / \$560M	1wk – 200wks / 165 Wks
2. Install select mains in alleys - 6" mains and greater / 50% (250 mi)	\$400K - \$150M / \$100M	1wk – 85wks / 55 Wks
3. Keep meters at inside non basement locations and relocate regulators to outside location / 25% (11,500 mtrs)	\$100K - \$253M / \$85M	0.5wk – 1,300wks / 450 Wks
4. Reduce the number of rail crossings impacting program / 25% (38 ea)	\$650K - \$50M / \$25M	16wks – 1,200wks / 600 Wks
5. Reduce Program schedule (escalation) by one year / 6% (52 weeks)	\$120M / \$120M	52wks / 52 Wks

**Assumes no change in crew size supporting activity. These are NOT critical path weeks, though some weeks may fall on the critical path.*

In addition to the quantifiable savings listed above, there are a number of non-quantifiable efforts that should be further evaluated to drive improvements to the baseline cost estimate and schedule including:

- Expand construction contracting pool
- Expand 3rd party engineering pool
- Review/revise engineering and construction contracts
- Evaluate contracting options
- Assess large diameter Cast Iron and need for replacement
- Assess existing work rules
- Owner Controlled Insurance Program (OCIP)
- Holistic view of distribution system capacity and design
- Take or pay material contracts

To improve the P80 (probabilistic cost and schedule), the focus needs to be on performance consistency – narrowing the band between the low end and high end limits discussed earlier. Some ways to improve performance consistency include dedicated resources for select activities for more predictable execution - removing the day-to-day variance on performance, or improving consistency through automation – such as the automated fusion machines that reduce cycle times, improve quality and reduce rework. Other opportunities include:

- Dedicated resources for select activities
 - Markings / Meters
 - Restoration
- Retirement Streamline permit process (internal and City)
- Improved utility marking
- Improved contract oversight
- Innovation / automation
 - Leverage GPS
 - Cloud linked fusion equipment

Appendix A - Neighborhood Maps

Map	Neighborhood	Intersection	Borders	Line	Traffic (trains/day)		Gas crossing
					Freight	Passenger	
	9 Edison Park	Pratt	N/A	UP	1-3	65	
	9 Edison Park	Devon	N/A	UP	1-3	65	
	9 Edison Park	Ockbrook	N/A	UP	1-3	65	

